Kinetic full wave analysis of EC wave mode conversion by integral operator method

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Kinetic description of wave propagation and absorption in inhomogeneous plasmas has been proposed in various schemes for quantitative analysis. Most of them have limitations due to the use of a local kinetic dielectric tensor for a fixed wave number. For a more practical description, an integral form of dielectric tensor has been introduced by transforming the velocity integral into the positional integral of the wave electric field along the particle orbit. Then, the induced current is expressed in the integral form without a wave number. This technique provides a sufficiently accurate scheme for quantitative kinetic full wave analysis of wave heating and current drive (CD) in magnetic fusion plasmas. The full wave method solves the Maxwell's equation as a boundary value problem for a given frequency which is complex in general.

In heating and CD in tokamak plasmas in the range of electron cyclotron (EC) resonance frequency, efficient mode conversion of the EC wave to the electron Bernstein wave (EBW) and its behavior are vital. Hansen et al., [1] have introduced an integral form of dielectric tensor and proposed OXB mode conversion for high-field-side injection with an optimum injection angle for EBW penetration. Finite-Larmor-radius effects have been included by the inverse Fourier transform of the modified Bessel functions [2]. Recently, a more general approach based on particle orbits was implemented and applied to the one-dimensional analysis of O-X-B mode conversion [3].

For low-field-side excitation in toroidal configuration, OXB mode conversion for an optimum injection angle is required for penetration into high density region. Two-dimensional (2D) analysis of OXB mode conversion on the horizontal plane and poloidal cross section has shown various parameter dependencies of the wave structure and power deposition profile. Typical 2D analysis on the horizontal plane in a tokamak configuration is shown in Figure 1. The static magnetic field along the vertical axis is straight and uniform. Magnetic field strength and plasma density are increasing leftward. The O-mode is excited near the lower-right corner, then mode-converted to the X-mode and reflected in the central region, reflected again near the upper hybrid resonance (UHR) layer and mode converted to EBW, which is finally absorbed near the cyclotron resonance located at the plasma center. Consistency of the study with the experimental observations has been verified in the presence of a small amount of collisions. Preliminary analysis on the poloidal plane including the poloidal magnetic field will also be presented.

References

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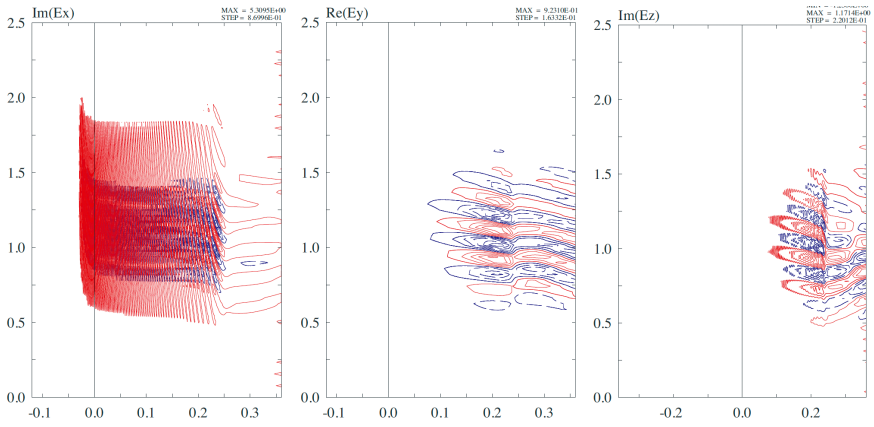

Figure 1. *O-X-B mode conversion on horizontal plane of slab configuration of tokamak*